3.G.16 f. (cont'd) Premature bulb failure on vessels such as tugs and barges, problems with vibration and shock (impact) have been reported. Although navigation lights are subjected to stringent vibration testing, with bulb failure as a rejection factor (evidenced by one manufacturer failing this test and having to re-design the fixtures), the accepted fixtures are not tested for impact shock. When shock or vibration is a problem, shock mounting the fixture is recommended. This shock mounting can take two forms. The first is internal isolation of the bulb. This is a manufacturer's modification and could involve retesting of the fixture. The second is to isolation mount the fixture on the vessel.

Another factor that has contributed to premature failure of lamps is inadequate voltage regulation. A 10% increase in voltage will reduce bulb life to approximately 25% of its rated life. Thus, any action to ensure proper voltage at the fixture will help to extend bulb life.

Screens. Annex I of the International Regulations for Preventing Collision at Sea, 1972 (72 COLREGS) and Annex I of the 1980 Inland Navigation Rules require sidelights on vessels over 20 meters in length to have external screens. These screens are to be painted matte black. Therefore, all sidelight fixtures on U.S. Coast Guard certificated vessels greater than 20 meters in length must have screens painted matte black for the sidelights.

The sidelight screens may be utilized to obtain the required cut-off angles for the sidelights as required by Section 9 of Annex I to the 72 COLREGS and section §84.17 of the 1980 Inland Rules. If the sidelight fixtures are fitted with internal screens that provide the proper cut-off angles, an external screen must still be provided to meet the 72 COLREGS as well as the Inland Rules. The installation of an internally screened sidelight in conjunction with an inboard external screen, if properly aligned, would meet the requirements.

In addition to sidelights, other navigation lights (such as masthead and anchor) have horizontal sector cut-off requirements. Most manufacturers have used internal screens to achieve the required cut-off, but external screens would also be acceptable, although they are not required. These fixtures would be required to be marked with an indication that they are to be installed with external screens.

g. Barge Lights (Battery Powered) Exemptions. International Regulations for Preventing Collisions at Sea, 1972, (72 COLREGS); Lights for Unmanned Barges, COMDTINST M16672.3 (series) has exempted battery powered barge lights from the vertical sector cut-off requirements of the 72 COLREGS. It is only applicable to unmanned barges without machinery for the generation of electricity or with such machinery intended for operation only while moored. The 1980 Inland Rules permanently exempt electric navigation lights on unmanned barges from the vertical sector requirements.

17. Hazardous Locations (46 CFR 111.105).

a. General. Where flammable gases or vapors may be present, such as on the drill floor of a Mobile Offshore Drilling Unit or in the pumproom of a tankship, special precautions must be taken to ensure that

3.G.17 a. (cont'd) electrical equipment is not a source of ignition. Subpart 111.105 of the Electrical Engineering Regulations contains the requirements for electrical equipment and wiring in locations where fire or explosion hazards may exist. In these locations, it is necessary to exercise more than ordinary care with regard to the selection, installation, and maintenance of electrical equipment and wiring. A primary objective of design should be to minimize the amount of electrical equipment installed in hazardous locations. Through the exercise of ingenuity in the layout of electrical installations for hazardous locations, it is frequently possible to locate much of the equipment in less hazardous or in non-hazardous areas and thus reduce the amount of special equipment and installations required.

b. Protection Types. The various methods by which electrical and electronic equipment is made safe for use in hazardous areas may be divided into two major categories: (1) protection by enclosure or other physical separation between the electrical equipment and the hazardous atmosphere; and (2) protection by electrical design (making the circuitry unlikely to produce ignition of the hazardous atmosphere). Examples of the first category include explosion-proof and purged and pressurized enclosures, as well as oil immersion. The second category includes the intrinsically safe and nonincendive safety techniques.

(1) Ignition Protection. Ignition-protection is another type of protection by design. Ignition-protected devices are intended for use aboard recreational boats and uninspected vessels in enclosed spaces that may occasionally contain gasoline vapors. They meet the testing requirements of UL 1500, which are not as stringent as those for explosion-proof or intrinsically safe equipment. Ignition-protected equipment is not suitable for use in hazardous locations on inspected vessels other than oil recovery vessels.

(2) Intrinsically Safe. This is the only method that uses electrical protective measures to prevent ignition from electrical faults. Intrinsically safe equipment is used in both Zones 0 and 1 and Division 1 areas.

(3) Explosion Proof Vs. Flame Proof. Explosion proof enclosures are used in the U.S. and Canada while flameproof enclosures are used elsewhere. Both types of enclosure have flame paths that cool the gases as they escape from the enclosure. What is notable here is that flameproof equipment is designed to meet IEC 60079-1 and/or CENELEC Standard EN50018. With a choice of standards to conform to, there are varying differences in flameproof equipment from country to country.

(4) Type "n" Protection. Type of Protection "n"- (Article 505 of the NEC and IEC 60079-15) Type "n": protection is a type of protection applied to electrical equipment such that in normal operation, the electrical equipment is not capable of igniting in a surrounding explosive gas atmosphere and a fault capable of causing ignition is not likely to occur. This type of equipment is allowed in Europe, U.S. and Canada in Class 1 Zone 2 areas.

3.G.17 c. Classification. National and international codes and regulations classify materials and locations based upon the experimentally determined properties of flammable vapors, gases, liquids, or combustible dusts or fibers that may be present and the likelihood that a flammable or combustible concentration or quantity is present. North American standards identify hazardous locations by Class and Division using the scheme described in Tables 1 and 2 (3.G.17.f). International standards (such as IEC Standard 60079-10) use a different nomenclature, but their classification philosophy is mostly the same.

For Class I locations, gases and vapors are divided into groups A, B, C, or D, depending upon experimentally determined maximum explosion pressure, maximum safe clearance between parts of a clamped joint in an enclosure, and the minimum ignition temperature of the atmospheric mixture. For Class II locations, dusts are divided into Groups E, F, and C, depending upon the tightness of the joints of assembly and shaft openings for preventing entrance of dust into the dust/ignition proof enclosure, the blanketing effect of layers of dust on the equipment that may cause overheating, electrical conductivity of the dust and the ignition temperature of the dust. In general, equipment must be approved not only for the Class, but also for the specific Group of the gas, vapor, or dust that may be present. Flammable and combustible liquid cargoes may be further classified according to their vapor pressure and flashpoint. These liquids may be assigned both a Group and a Grade (Grade designation relates to flashpoint). In cases where differing requirements apply or several different hazardous atmospheres may be present, the most hazardous condition is presumed to exist and the most restrictive requirements should be applied.

Once a specific location is classified, and specific materials that may be present are identified, the permitted types of electrical equipment are easily determined. For example, an area containing gasoline vapors would require Class I, Group D equipment. Where vapors would be present under normal conditions, the area would be a classified as Division 1, and equipment must be suitable for use in a Class I, Division 1, Group D location.

This classification system requires the use of some individual judgment, especially in the designation of "Division." To promote consistency and ensure safety, standard setting bodies and regulatory agencies have developed detailed standards, recommended practices, codes, and regulations applicable to specific situations.

The IEC 60079-XX "Electrical apparatus for explosive gas atmospheres" series of standards are based upon the concept of Zones. These standards separate the North American classification of Division I into Zone 0 and Zone 1. Zone 0 identifies those areas where "flammable gases are present continuously or for long periods of time and takes more restrictive measures to protect against electrical ignition". Thus only intrinsically safe apparatus or equipment can be used. Explosion-proof and pressurized equipment are not allowed for use in Zone 0 classified areas.

Zone 1 is classified as less hazardous then Division 1. In an area classified as Zone 1, less restrictive practices other than explosion

3.G.17 c. (cont'd) proof or purging can be used. Arcing devices, however, must still be housed inside explosion-proof enclosures.

d. Specific Hazardous Areas. Locations where flammable gases or vapors can exist on commercial vessels include battery rooms, paint lockers, pumprooms and weather deck locations above cargo tanks on tank vessels, mud pit rooms and the drill floor of Mobile Offshore Drilling Units, and operating rooms where anesthetics are administered on passenger vessels and hospital ships. 46 CFR 111.105 defines specific hazardous locations for combustible liquid cargo vessels, flammable liquid cargo vessels, liquid sulphur carriers, inorganic acid tankships, bulk liquefied gas and ammonia carriers, MODU's, vessels carrying coal, and vessels (such as ferries and RO-RO's) with spaces for the carriage of vehicles using gasoline or other highly volatile motor fuels. Typical hazardous location classifications are illustrated in section 3.G.17.d (7). Note the IEC "Zone" approach is also allowed by 46 CFR 111.105 and the NEC.

The Electrical Engineering Regulations define particular areas to be Division 1 or Division 2 locations; there is no "Division 0" in the Division scheme comparable to the IEC Zone 0 designation. In the Division scheme, spaces where the hazard is assumed to be present under normal conditions are classified as Division 1 locations. There is no "higher" classification (i.e., Division 0). Enclosed locations comparable to tank vessel pumprooms typically do not exist in National Electrical Code applications. On shore, such installations are usually located in the weather, and spread-out over a much larger area. In Coast Guard regulations, spaces comparable to "Zone 0" locations such as pumprooms on tank vessels, while not given a Division 0 designation, are permitted only limited electrical equipment (i.e. explosion-proof lights, intrinsically safe systems, and cables) similar to IEC Zone 0 requirements.

Combustible liquids (see definition in 46 CFR 30.10-15) are often referred to as Grade D and Grade E cargoes. Similarly, flammable liquids (defined in 46 CFR 30.10-22) may be classified as Grade A, B, or C cargoes. Due to the high flashpoints of Grade E liquids, vessels carrying only Grade E cargoes need only meet the requirements of 46 CFR 111.105-29 for combustible liquid cargo carriers. The requirements of 111.105-31 apply to vessels carrying combustible or flammable cargo with a closed-cup flashpoint lower than 60°C (140°F), as well as liquid sulphur and inorganic acids. Note that in accordance with 46 CFR 30.10-15 Grade D cargo may fall above or below the 140°F cutoff. Flammable hydrogen sulfide gas evolves from liquid sulphur, and many inorganic acids produce hydrogen gas when in contact with a number of common construction metals.

(1) MODU's. On MODU's, a specific classification for crude oil cannot always be given, since crude is a mixture of widely varying hydrocarbons. Locations are usually, however, designated Group D due to the presence of natural gas. Hydrogen sulfide, which is frequently encountered during drilling operations, has a Group C designation. Drilling operators often utilize electrical equipment that is suitable for both hazard groups C and D, especially when this equipment is readily available, and there is no economic penalty. It should not be inferred from the presence of some Group C equipment that the area has been classified as a

3.G.17.d (1) (cont'd) Group C area. A Group D classification should be adequate when drilling in a region where the known or suspected mixture of hydrogen sulfide and natural gas is less than 25 percent hydrogen sulfide (by volume). Coal carriers and vessels carrying bulk grain and other agricultural products may be subject to dust explosion hazards. Just as with flammable gas or vapor explosions, the initial ignition source of a dust explosion may be a small spark or flame. However, an initial explosion may dislodge settled dust from the surrounding area that may then be ignited by the residual energy to cause a second and larger explosion.

Undispersed dust that has accumulated in layers will not explode but may burn or char; generating heat that may ignite dispersed dust. NEC Article 502 lists the primary hazards that must be avoided as the admission of dusts into electrical equipment enclosures, reaching the heat of ignition due to the insulating characteristics of accumulated dust, and the formation of current paths of conductive dusts.

Explosion hazards due to agricultural dusts are not specifically addressed in the Electrical Engineering Regulations. However, 46 CFR 111.105-17 and 111.105-35 do give the requirements for electrical installations in Class II locations and specific requirements for vessels carrying coal. NVIC 9-84

(2) Agricultural Dust Areas. Electrical Installations in Agricultural Dust Locations further defines the classification of hazardous areas due to agricultural dusts. It must be remembered that the enclosure protection method is different for dust than it is for a gas or vapor, and that "dust ignition-proof" and "explosion-proof" are two different concepts. For a dust, the enclosure keeps dust out and does not build-up excessive temperatures when blanketed with dust. For a vapor, the enclosure allows vapor to enter and be ignited, yet prevents the internal explosion from propagating to the surrounding atmosphere. Equipment acceptable for use in a dust atmosphere is not generally suitable for use in a gas atmosphere, and vice-versa.

(3) Coal. Vessels carrying coal may be subject to the double hazard of explosive gas as well as explosive dust. Freshly mined coal releases methane gas that had been contained within the pores of the coal. Release of methane can continue for days and even weeks after the coal is mined. If freshly mined coal is stored in an enclosed space, such as a bunker or closed hold on a ship, this methane may collect in sufficient quantity to cause an explosion.

(4) Battery & Paint Stowage Rooms. Battery rooms and paint stowage or mixing spaces must meet the electrical requirements of 46 CFR 111.15 and 111.105-41 & 43, respectively. The regulations do not explicitly state that these spaces are defined as hazardous. However, equipment within these spaces must be suitable for installation in Division 1, Zone 0 or Zone 1 locations. The hazardous locations are considered to exist only inside these spaces; the regulations do not define a hazardous area as extending any specific radius from doors, hatches, or other openings into these spaces. The use of only explosion-proof or

3.G.17.d (4) (cont'd) intrinsically safe electrical equipment and the avoidance of open flames and sparking near such openings is, however, strongly recommended.

(5) Armored Or Mineral Insulated Cable. The Electrical Engineering Regulations require armored or mineral insulated cable for most installations in hazardous locations. Unarmored cable is permitted for intrinsically safe systems, portable equipment, applications requiring flexible cable, and in Division 2 locations. Industrial systems may use an armored type cable construction, but the cable must also meet the installation and flammability test requirements of 46 CFR 111.107-1(c) if it penetrates a deck or bulkhead. Conduit systems that meet the applicable requirements of the NEC provide an equivalent level of safety and can be permitted.

(6) Stowage Of Vehicles With Gasoline In Tanks. The minimum safety requirements for electrical equipment located in spaces intended for the stowage of vehicles with gasoline in their tanks and batteries connected are contained in 46 CFR 111.105-39. These requirements apply to spaces designated as specially suitable for vehicles" on passenger and cargo vessels It should be noted that SOLAS II-2/37.1.6, 37.2.2, and 37.3.2 contain somewhat different requirements for ventilation and precautions against ignition of flammable vapors in "special category spaces", which are those vehicle stowage spaces on passenger vessels normally accessible to passengers. Regulations 38.3 and 38.4 address these issues for other vehicle cargo spaces on passenger vessels. Similarly, SOLAS 11-2/53.2.3 and 53.2.4 state the ventilation and ignition prevention requirements for vehicle spaces on cargo vessels, including RO/RO spaces. While 46 CFR 111.105-39 is considered to provide sufficient minimum requirements for the prevention of ignition by electrical equipment, closed spaces for fueled vehicles should be provided with ventilation per ABS Section 5-10-4/3 and SOLAS 11-2/53.2.3.

(7) Specified Hazardous Location Table.

Specified Hazardous Locations				
Locations	Class I Div. 1	Class I Div.2	Class II	Class III
Cargo Tanks*	NA	NA	NA	NA
Cargo Handling Rooms*	NA	NA	NA	NA
Cofferdams*	NA	NA	NA	NA
Battery Rooms	X	NA	NA	NA
Paint Storage Rooms	X	NA	NA	NA
Paint Mixing Rooms	X	NA	NA	NA
Oil Storage Rooms	X	NA	NA	NA
Anesthetic Handling Area	X	NA	NA	NA
Tank Vessel Weather deck 10 ft. Rule	X	NA	NA	NA
Tank Vessel Weather deck Cargo Block	X	NA	NA	NA
Flammable Gas Handling Room*	NA	NA	NA	NA

Specified Hazardous Locations				
Locations	Class I Div. 1	Class I Div.2	Class II	Class III
Flammable Liquid Handling Room*	NA	NA	NA	NA
Adjacent to Class I, Div. 1 w/Communication	X	NA	NA	NA
Tank Vessel Enclosed Space Adjacent to Cargo Tank*	NA	NA	NA	NA
Grain Handling Area	NA	NA	X	NA
Coal Handling Area	NA	NA	X	NA
Coal Pulverizing Area	NA	NA	X	NA
Carpenter Shop	NA	NA	NA	X
Fiber Handling Area	NA	NA	NA	X
Vent Duct	Same as Space Served			
Tank Vessel Cargo Hose Stowage Space*	NA	NA	NA	NA
Space Containing Cargo Piping only, on Tank Vessels*	NA	NA	NA	NA
LFG Barrier Space*	NA	NA	NA	NA
Enclosed Space Opening to Weather Deck Haz. Area	X	NA	NA	NA
Tank Vessels Within 8′ of Cargo Containment System	X	NA	NA	NA
Tank Vessels, Within 10′ of Cargo Handling Room Door or Vent	X	NA	NA	NA
Vessel Fuel Oil Tanks, 10′ Rule Does not Apply	X	NA	NA	NA
Tank Vessel, A-D Cargoes, Area From 3m to 5m of PV Valves	(see SOLAS II-2/59.1.7.2)			
	NA	X	NA	NA
Tank Vessel, A-D Cargoes, Area From 3m to 10m of Vent Outlets for Free Flow of Vapors and H.V. Vents for Loading or Discharge	(see SOLAS II-2/59.1.9.3)			
	NA	X	NA	NA

Note: These areas are considered more hazardous than Class I, Division 1 and therefore carry specific requirements in 46 CFR 111.105-29, 111.105-31, and 111.105-32

e. Electric Heat Tracing. Questions frequently arise concerning the acceptability of electric heat tracing in hazardous locations. Heat tracing is permitted in Division 2 locations by NEC Article 501-10(b)(1). Since the NEC requires wiring in Division 1 locations to be in conduit, it does not recognize heat tracing cable installations in Division 1 locations. However, since shipboard Division 1 installations use cable, not conduit, and Subchapter J does not reference the NEC for Division 1 wiring methods, electric heat tracing may be used in Class I Division 1 locations. The heating cable must not exceed 80% of the auto-ignition temperature in degrees Celsius of any gas or vapor involved on any surface, which is exposed to the gas or vapor, when continuously energized at the maximum rated ambient temperature. Any thermostats, controllers, power supplies, 3.G.17 e. (cont'd) and other associated equipment must be provided with enclosures approved for Class I Division 1 locations or be located outside of the designated hazardous areas.

f. Hazardous Area Drawings. Hazardous area drawings and a corresponding bill of materials are normally reviewed by the Marine Safety Center, or cognizant OCMI, prior to the installation of any electrical equipment in a hazardous location. Hazardous area drawings and equipment lists should be maintained to reflect the current arrangement and inventory of electrical equipment in those locations.

A proper hazardous area drawing is an arrangement plan showing the boundaries and classification of all hazardous areas, and the location of all electrical equipment in those areas. It should be accompanied by a bill of material or equipment list that identifies each item by manufacturer, model number, and Class and Group for which approved, and should provide evidence of approval by a nationally recognized testing laboratory. In addition, the operating temperature of the electrical equipment must not exceed the auto-ignition temperature of the gases or vapors likely to be present. Confirmation of equipment temperature is usually beyond plan review capabilities, since it is not usually provided in approval listings. This information is required on the label of explosion-proof equipment in the form of an operating temperature identification code number on the equipment if the temperature exceeds 100 degrees C. (see Table 3 at 3.G.17.j(2)). Normally, the only equipment installed in hazardous locations having a temperature code will be incandescent lighting fixtures and motors. When such equipment is used in a machinery space, a 50 degrees C. ambient is assumed. The labeled operating temperature is usually referenced to a 40 degree C. ambient. Unless the equipment has thermally actuated sensors that limit the operating temperature to that specified on the label, equipment in high ambient temperature locations should be derated.

NVIC 8-84, "Recommendations for the Submittal of Merchant Vessel Plans and Specifications" provide additional guidance on hazardous area submittals.

RECOMMENDED PLAN REVIEW CHECK-OFF FOR HAZARDOUS LOCATIONS

1. Has sufficient information been provided?

(a) Hazardous cargoes;

(b) An arrangement plan identifying hazardous and non-hazardous areas, cargo system or hazards, electrical equipment type and locations;

(c) A complete and detailed Bill of Materials;

(d) Elementary and one-line wiring diagrams, showing all wiring;

(e) Electrical installation details;

(f) Nationally Recognized Testing Laboratory (NRTL) label or listing for explosion proof (EP) and intrinsically safe (Is) equipment and systems; and

3.G.17.f.1 (g) Maximum temperature ratings of electrical equipment in hazardous areas.

2. Identify hazardous characteristics:

(a) Class and group;

(b) Flashpoint and grade;

(c) Minimum ignition temperatures; and

(d) Special requirements, including material compatibility.

3. Confirm boundaries of hazardous locations and suitability of equipment installed.

4. Confirm that the installation meets:

(a) Subchapter J;

(b) Intended application by a NRTL (currently UL, FM, CSA, and MET are Acceptable to the Coast Guard)

(c) Specific requirements for the cargo/material; and

(d) General considerations of this NVIC.

Table 1

Classification of Properties of Hazard-Producing Materials

Class I -- Locations where flammable gases or vapors may be present, including:

Group A: Atmospheres containing acetylene.
Group B: Atmospheres such as butadiene, ethylene oxide, propylene oxide, acrolein, or hydrogen (or gases or vapors equivalent in hazard to hydrogen)
Group C: Atmospheres such as cyclopropane, ethyl ether, ethylene, or gases or vapors of equivalent hazard.
Group D: Atmospheres such as acetone, alcohol, ammonia, benzene, benzol, butane, gasoline, hexane, lacquer solvent vapors, naphtha, natural gas, propane, or gases or vapors of equivalent hazard.

Class II -- Locations where combustible dust may be present, including:

Group E: Atmospheres containing combustible metal dusts or other combustible dusts or similarly hazardous characteristics.

Group F: Atmospheres containing combustible carbon black, charcoal, coal, or coke dusts.
Group G: Atmospheres containing combustible agricultural or plastic dusts.

Class III -- Locations where easily ignitable fibers or flyings, such as cotton fibers, sawdust, and wood shavings, may be present.

3.G.17.f (cont'd)

Table 2

Classification of the Probability that Material May Be Present in Flammable or Combustible Quantities

Division 1: (Zone 1)	Where material can exist under normal operating conditions, or frequently because of repair, maintenance, or leakage.
Division 2: (Zone 2)	Where material can exist under abnormal conditions (accidental rupture or breakdown, abnormal operations, etc.), or locations adjacent to a Division 1 location where material may occasionally be present.

Note: International standards use the term "Zone" instead of "Division" and include a "Zone 0" designation for locations where vapors are assumed to be present, such as inside a tank or in a tankship pumproom. A comparable "Division 0" does not exist in the Division classification scheme. Coast Guard regulations achieve the same effect as a "Division 0" by limiting electrical installations in applicable locations to the type permitted for Zone 0 locations. Many domestic standards as well as Coast Guard regulations now include the Zone approach.

g. Equipment. Specific requirements for electrical equipment in hazardous locations are contained in 46 CFR 111.105. In that subpart, certain equipment is required to be listed an independent laboratory recognized by the Commandant (G-MSE-3) for use in the hazardous location in which it is located. "Listed" means equipment included in a list published by an U.S. Coast Guard accepted independent test laboratory concerned with product evaluation, that maintains periodic inspection of listed equipment and whose listing states either that the equipment meets appropriate standards or has been tested and found suitable for use in a specified manner.

(1) Division 1 Equipment. The following general considerations apply to equipment selection and installation: Division 1 equipment is satisfactory for Division 2 applications with the same Class and Group. Note that the explosion-proof equipment label may not say "Division I." If the label says it is suitable for Class I Group (__) locations, it means it is suitable for both Division 1 and Division 2 locations.

(2) Class 1 Division 2 Make And Break Contacts. NEC Section 501-3(b)(1) requires devices in Class I, Division 2 locations, with make-and-break contacts to be within an enclosure approved for Class I, Division 1 locations or to be in a general-purpose enclosure with the current interrupting contacts either immersed in oil, enclosed in a hermetically sealed chamber, or in only nonincendive circuits.

Examples of make-and-break contacts include relays, circuit breakers, servo-potentiometers, adjustable resistors, switches, connectors, and motor brushes. A nonincendive circuit is a

3.G.17.g (2) (cont'd) circuit in which any arc or thermal effect produced under intended operating conditions of the equipment is not capable of igniting the specified flammable gas or vapor-air mixture. A hermetically sealed device is one which is manufactured so that it is completely sealed against entrance of an external atmosphere and in which the seal is made by soldering, brazing, welding, or fusion of glass, or the like.

(3) General Purpose Enclosures. NEC Section 501-3(b)(2) permits general-purpose enclosures to be used in Class I, Division 2 locations for resistance devices and similar equipment used with meters, instruments, and relays provided such equipment is without make-and-break or sliding contacts and the maximum operating temperature of any exposed surface will not exceed 80% of the ignition temperature of the gas or vapor involved.

(4) Belt Drives. Belt drives are acceptable if the belt is conductive and the equipment is grounded in accordance with NFPA 77. Acceptable belts have a resistance of approximately 6 mega ohms or less over an eight inch length, as determined by an industry standard test procedure, and are commonly designated as "static conductive."

(5) Cables. Cables must not be located in any tanks containing flammable or combustible liquids, except to supply equipment or instrumentation specifically designed for, and compatible with, such location, and whose function requires installation in that location.

(6) Vent Ducts. Vent ducts have the same classification as the space they serve. Fans for ventilating hazardous locations must be nonsparking as defined in ABS 4-8-3/11. Nonsparking construction is not generally indicated by an independent laboratory listing, and must usually be verified by review and/or inspection. Vent fan motors must either be approved for the hazardous location or located outside the duct, 10 feet from the duct termination, in a non-hazardous area.

(7) Alloys. Alloys of aluminum, magnesium, and titanium, when struck by rusty steel, react with the iron oxide to produce a highly exothermic "thermite reaction." Care must be taken to provide adequate physical separation and/or surface coatings where these metals are used in moving components around steel. The most important thing to remember is that equipment rated for Division 1 or 2 can be used in Zone 1 or 2 respectively. However, equipment rated for Zones cannot be installed in areas classified as Division 1 or 2.

h. Intrinsic Safety and Nonincendive Systems. For low power applications, such as instrumentation, control, and operation of solenoid valves, the use of intrinsically safe and nonincendive systems can reduce the likelihood of fire or explosion due to the ignition of flammable gas mixtures by electrical arcs or high temperatures. However, safety depends on their proper application, as these two forms of protection are not equal.

3.G.17 h. (cont'd) Section 501-3 of the NEC states: In Class 1, Division 2 locations, switches, circuit breakers, and make-and-break contacts shall have enclosures approved for Class 1, Division 1 locations. EXCEPTION: General-purpose enclosures shall be permitted, if current-interrupting contacts are... in circuits that under normal conditions (emphasis added) do not release sufficient energy to ignite a specific ignitable atmospheric mixture, i.e., are nonincendive. The word "nonincendive" means that under the conditions specified, there is insufficient energy to cause ignition. Nonincendive systems are only permitted in Division 2 and non-hazardous locations.

(1) Nonincendive Systems. Nonincendive circuits are similar to intrinsically safe circuits, but no fault conditions or safety factors are applied, as the existence of a hazardous atmosphere in a Division 2 location is itself considered a fault condition.

In the past, much of the nonincendive circuitry that found its way into Division 2 locations was neither designed nor intended for use in hazardous locations. Only when a Division 2 application arose for a specific item was the circuit examined to see if it was nonincendive. Regulatory bodies typically reviewed manufacturer's analyses to see if voltage and current levels fell below the appropriate ignition curve with a reasonable margin of safety. If they did, the circuit was accepted to be nonincendive.

Today, much of the equipment installed in Division 2 locations has been designed to be nonincendive. This is especially true of sophisticated electronic equipment used in the drilling industry. Furthermore, manufacturers are recognizing the value of independent third-party approvals. In North America, standard setting bodies, such as the Instrument Society of America, Underwriters Laboratories Inc., and the Canadian Standards Association, have published or are presently developing safety standards for nonincendive equipment. Third-party certification agencies are using these standards to evaluate and list or label nonincendive equipment.

Listed or labeled equipment provides the end user with a greater degree of confidence that the nonincendive equipment has been properly evaluated and will not present an unnecessary risk of fire or explosion. However, manufacturer certification of nonincendive circuits is acceptable; certification by a third-party testing agency is not required, and many acceptable nonincendive circuits bear no label or other marking by these agencies.

(2) Intrinsically Safe Systems. Section 500- 4(e) of the 1987 NEC states: Intrinsically safe apparatus and wiring shall be permitted in any hazardous (classified) location for which it is approved. Intrinsically safe equipment and wiring shall not be capable of releasing sufficient electrical or thermal energy under normal or abnormal (emphasis added) conditions to cause ignition of a specific flammable or combustible atmospheric mixture in its most easily ignitable concentration. Additional guidance on intrinsically safe installations is expected to be included in Article 504 of the NEC.

3.G.17.h (2) (cont'd) Intrinsically safe portable battery-powered equipment, such as walkie-talkies and combustible gas detectors, are evaluated based on their internal circuitry. However, equipment that is interconnected to other equipment, such as to the vessel's electrical system, is evaluated on a system basis. Since evaluations for intrinsic safety consider failure modes, faults in connected apparatus such as power supplies, meters, and recorders (regardless of their location, i.e., hazardous or non-hazardous) may affect energy levels in the circuit, and are fully evaluated.

In determining available energy levels, abnormal conditions include opening, shorting, and grounding of wires connected to the enclosures in the intrinsically safe portion of the system. In North America, two "reasonable" simultaneous faults are considered in assessing available electrical and thermal energy. Industry standards give detailed criteria for determining reasonable failure modes. Evaluations usually involve an in-depth circuit analysis, supplemented by actual ignition testing.

Intrinsically safe systems and portable equipment must be tested and approved for the intended application by a nationally recognized testing laboratory. For installed systems, listing reports should be reviewed to ensure that restrictions placed upon the equipment by the certification agency are recognized in the installation. In general, switches and other simple devices that do not store energy can be in hazardous locations when used with approved intrinsic safety (Zener) barriers that limit the energy in the circuit.

(3) Installation. Safety also depends on proper installation. It is necessary to ensure that the system is connected correctly and that unsafe energy levels are not induced in intrinsically safe circuits by nearby non-intrinsically safe circuits. In evaluating intrinsically safe systems, it is important to know the restrictions imposed by the certification agency, and to have the installation information available that verifies that the restrictions, such as installed cable impedance, have been met. The following installation requirements should be followed:

(a) Cables for use in intrinsically safe installations should meet the standards of 46 CFR 60-1. However, since intrinsically safe circuits are inherently power limited, cable constructions other than those specified in 111.60 may be accepted, provided the cable has an adequate voltage rating.

Many specialty cable types, which are not constructed to meet the standards referenced in 46 CFR 111.60, are used in intrinsically safe circuits, particularly in industrial systems such as down-hole well testing instrumentation. Flame propagation is a concern with any cable that penetrates a deck or bulkhead. If a particular cable type is self-extinguishing, but cannot comply with the IEEE-45 or IEC 60332-3 (Cat. A) fire tests, then it may be run singly (not in or near bundles or cable trays with other cables).

3.G.17.h(3)

(b) Equipment in weather locations must be made watertight.

(c) Cable insulation must be compatible with the environment. Some installations may be in cargo tanks.

(d) As a general rule, conductors should be no smaller than #18.

(e) Cables for intrinsically safe systems must be isolated from other cables to prevent compromise due to induction or insulation breakdown. This is to be accomplished by maintaining two inch spacing, or by using grounded metal barriers or shielded cable.

(f) At a termination, intrinsically safe circuits must be isolated from other intrinsically safe circuits, other low-energy level circuits, and all power circuits (see ISA RP 12.6).

(g) More than one intrinsically safe circuit of the same system may be run in a multiconductor cable (see ISA RP 12.6).

(h) Cables containing conductors for intrinsically safe systems must not contain conductors of non-intrinsically safe systems.

(i) In general, an intrinsically safe barrier should be located in a non-hazardous location. If it is in a hazardous location, the barrier itself must be suitable for the location.

(j) Energy storing equipment must be explicitly approved by the certification agency when used with a barrier.

(k) Passive devices that do not store energy, such as switches, thermocouples, resistances, and LED's may be connected to barriers without further certification, provided they are not part of a unit containing other electrical circuits.

For low power applications, intrinsically safe systems offer advantages over "add-on" protection, such as explosion-proof or purged and pressurized enclosures.

A missing or loose bolt, a scratched flange, an unpoured cable seal, a stuck interlock, or mechanical damage does not jeopardize intrinsic safety. The intrinsically safe circuit is less maintenance dependent and provides a lifetime of protection with relatively little care.

Although the Electrical Engineering Regulations reference the 1976 edition of ISA RP 12.6 for cables in intrinsically safe systems, that standard may also be used for other aspects of intrinsically safe installations. The guidelines of the 1995 revision of this standard may also be followed. This later edition contains information on the combination of intrinsically safe apparatus under the entity concept, which allows users to determine acceptable combinations of intrinsically safe apparatus and connected associated apparatus that have not been tested and

3.G.17.h (3) (cont'd) approved for interconnection in such combination. This approach requires each intrinsically safe apparatus to have a control drawing that specifies parameters for the selection of the associated apparatus. The manufacturer provides the control drawing to specify the allowed interconnections between the intrinsically safe and associated apparatus.

i. Purged Or Pressurized Equipment. Purged or pressurized equipment and enclosures are permitted by the Electrical Engineering Regulations (46 CFR Subchapter J) for the protection of hazardous area equipment. The regulations require that this type of equipment be constructed to the National Fire Protection Association (NFPA) Standard 496, Purged and Pressurized Enclosures for Electrical Equipment.

Purged or pressurized systems pressurize the atmosphere within an enclosure with a non-hazardous gas (usually air from a non-hazardous location), thereby preventing the hazardous atmosphere from coming in contact with electrical equipment within the enclosure.

The NFPA standard addresses pressurized instrumentation and other small enclosures in Class I locations, power equipment enclosures in Class I locations, pressurized instruments and other small enclosures in Class II locations, and pressurized power equipment in Class II locations. The standard defines pressurization and purging as follows:

Pressurization: The process of supplying an enclosure with clean air or an inert gas with or without continuous flow at sufficient pressure to prevent the entrance of combustible dusts.

Purging: The process of supplying an enclosure with clean air or inert gas at sufficient flow and positive pressure to reduce to an acceptably safe level the concentration of any flammable gas or vapor initially present and to maintain this safe level by positive pressure with or without positive flow.

(1) Types. There are three types of purging protection in NFPA 496, Type X, Type Y, and Type Z. Type Z reduces the classification within an enclosure from Division 2 to nonhazardous. With type Z purging, a hazard is created only if the purge system fails at the same time that the normally nonhazardous areas become hazardous. For this reason, it is not considered essential to remove power from the equipment upon failure of the purge system.

Type Y purging reduces the classification within an enclosure from Division 1 to Division 2. The equipment and devices within the enclosure must be suitable for Division 2. This requires that the enclosure not contain an ignition source under normal conditions. Thus, a hazard is created within the enclosure only upon simultaneous failure of the purge system and of the equipment within the enclosure. For this reason, it is not considered essential to remove power from the equipment upon failure of the purge system.

Type X purging reduces the classification within an enclosure from Division I to nonhazardous. Because the probability of a hazardous atmosphere external to the enclosure is high and the

3.G.17.i (1) (cont'd) enclosure normally contains a source of ignition, such as a hot element or arcing contact, it is important that any interruption of the purging results in deenergizing the equipment. Also, it is essential that the enclosure be tight enough to prevent the escape of sparks. When type X purging is used in purged power equipment enclosures in Class I locations, power to the equipment should be immediately removed upon loss of pressurization, unless immediate loss of power would result in a more hazardous condition, such as not allowing for the safe shutdown of a process or system.

The NFPA standard presents some diagrams of acceptable installations for Types X, Y and Z purging. These diagrams are shown in 3.G.17.i(2). The NFPA standard requires that a nameplate be mounted on the enclosure in a prominent location so that it can be seen before someone opens the enclosure. The nameplate should contain the following statement (or equivalent):

"Enclosure shall not be opened unless the area is known to be nonhazardous or unless all devices within have been de-energized. Power shall not be restored after enclosure has been opened until enclosure has been purged for minutes." (Note: The blank must be filled-in by the manufacturer with the proper purge time).

It is apparent from this requirement that purged or pressurized enclosures should be designed in such a manner that normal operation of the equipment does not require that the enclosure be opened. Therefore, openings in the enclosures for inserting computer disks or slots for computer printouts and normal procedures that require the enclosure to be opened to retrieve data or take readings is not acceptable.

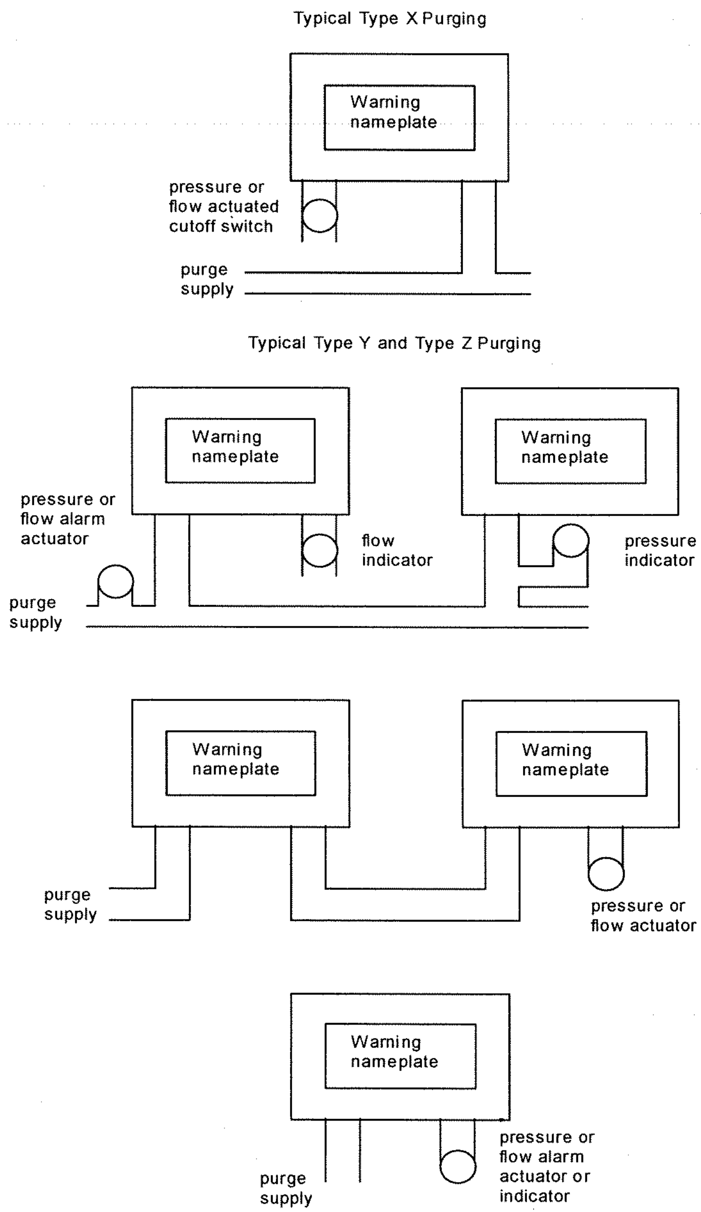
All three types of purging require the warning nameplate. Type X purging generally requires an interlock that immediately de-energizes all circuits that are not suitable for Division 1 areas. Type Y purging does not require an interlock but requires an alarm which operates when the enclosure is opened. Type Y is suitable for Division 1 if the internal components are suitable for Division 2. Type Z purging is suitable for Division 2 and requires an alarm, but does not place restrictions on internal components.

Purged or pressurized equipment may be used in lieu of explosion-proof equipment for all hazardous locations. Purged or pressurized equipment may not be used as a substitute for intrinsically safe apparatus. Purged or pressurized systems need not be approved by an independent testing agency, but are reviewed and approved for the particular application during vessel plan review.

Special care must be taken to ensure that the protective gas is from a non-hazardous source and cannot be contaminated by a hazardous source. Vent fan operation should be monitored by airflow, not simply by motor operation. Where it is necessary to open a purged or pressurized enclosure, for maintenance/repair, gas detection equipment maybe required so that a flammable atmosphere does not become trapped within the enclosure.

3.G.17.i (1) (cont'd) NFPA 496 recognizes the use of purged control rooms in Class I locations and pressurized control rooms in Class II locations. The requirements for control rooms may be used both for spaces that are structurally part of the vessel and for containerized compartments such as may be used for industrial functions aboard a MODU. Compressed air operated lighting fixtures (turbine lights) are both powered and purged by the air supply. These fixtures are acceptable for use in cargo handling rooms.

(2) <u>Purged and Pressurized Drawing</u>.



j. <u>Explosion-Proof Equipment</u>.

(1) <u>Enclosures</u>. When electrical equipment is installed where flammable gases and vapors may be present, an "explosion-proof"

3.G.17.j (1) (cont'd) enclosure may be used to allow the equipment to operate safely. The explosion-proof enclosure concept recognizes that flammable gases and vapors may enter the enclosure, and assumes that a source of ignition will create an internal explosion. The enclosure is designed to withstand the explosion and prevent it from propagating to the hazardous atmosphere surrounding the enclosure. Explosion-proof enclosures are not designed to be gastight, but are normally intended to "breathe." Flammable gases or vapors may enter an enclosure as it breathes due to changes in atmospheric pressure, ambient temperature, or both.

Conversely, gastight equipment is not explosion-proof. Explosion-proof enclosures usually have covers that can be removed or opened for making connections and adjustments, and for maintenance. The dimension of the gap between an enclosure's flanges and metal-to-metal joints determine its effectiveness. An explosion will propagate through this gap if the gap's width is greater than the maximum experimental safe gap (MESG). If the gap is less than the MESG, the velocity of the emerging jet of hot gases and the velocity of the external gases mixing with the jet are so great that cooling takes place and ignition cannot occur. When the hot gases from an explosion pass through this region, some energy is absorbed by the expansion of gases (refrigeration effect), and hot gases mixing with cool gases outside of the enclosure absorb some energy. Sufficient amount of energy must be transferred from the hot gases to the surrounding air or enclosure; otherwise, an explosion will occur.

Several explosion-proof enclosure cover types are used, depending on their application. The most simple and effective cover is a threaded joint. When an explosion occurs, the cover threads are forced tight against the body threads. Hot gases are cooled as they spiral along these threads. A gasket under the cover's flange is located outside of the cooling region and does not interfere with the metal-to-metal contact of the threads. Other types of enclosure openings or accesses include flanged and cylindrically shaped openings. These enclosures use precision-machined metal-to-metal joints that provide a straight path from inside the enclosure to the outside atmosphere. During an explosion, numerous cover screws prevent flange and enclosure distortion. Explosion-proof equipment in weather locations must be made watertight or waterproof. Explosion-proof enclosures are not normally designed to be watertight. In making these enclosures watertight, care should be taken that there is not interference with the flame-quenching surfaces and that gaskets are external to these surfaces.

When a flame ignites a gas, it may result in an explosion that causes a large increase in pressure. Due to the rapid increase in pressure, less energy is required for further ignition and flame propagation. An explosion occurs rapidly, causing a front between burned and unburned compressed gas. If the expanding gas is restricted, channeled, or impeded, pressure piling will occur. Pressures can occur which are ten times higher than pressures that occur when there is no impediment to expansion. Pressure piling is particularly serious in pipes and conduit. To reduce the effects of pressure piling, cable seal fittings must be

3.G.17.j (1) (cont'd) installed within eighteen inches of the enclosure for each conduit. Where two explosion-proof enclosures are connected and located less than 36 inches apart, only one seal is necessary in the conduit between them.

(2) Equipment. Equipment which is required by the Electrical Engineering Regulations to be explosion-proof must be specifically tested and approved by a nationally recognized testing laboratory for use in a Class I Division 1 location and the group of the hazard present, and be labeled as such.

In typical test programs, the enclosure is placed in a test chamber that has explosion pressure-recording devices attached to it. Both the enclosure and the chamber are charged with a specified gas. The gas inside the enclosure is ignited, and the resulting explosion is observed for propagation to the surrounding chamber's atmosphere. The explosion tests are repeated over the entire explosive range of the gas or vapor's fuel-air mixture. The enclosure must withstand the internal pressure from the explosion without bursting or loosening its joints. Explosion damage to equipment inside the enclosure must not occur during testing unless the damaged equipment can readily be replaced. All tests are conducted using maximum loads, short circuit, or worst-case conditions. Typically, ten tests are conducted over the entire flammable range for each device. Enclosures are tested for a period of one (1) minute using a hydrostatic pressure based on the max observed internal explosion pressure. Seals must withstand for one (1) minute a hydrostatic test pressure of four times the maximum explosion pressure.

Equipment that generates heat is evaluated to ensure that its surface temperature is not high enough to cause auto-ignition of the surrounding hazardous atmosphere. North American practice recognizes 14 temperature ratings for Class I locations. The Class I temperature ratings are listed in NEC Table 500- 5(e) and the Class II temperature limits are in NEC Section 500- 5(f).

TABLE 3
NEC ART. 500 - TABLE 500-3(b)

MAX. TEMP		
°C	°F	MARKING
450	842	T 1
300	572	T 2
280	536	T 2 A
260	500	T 2 B
230	446	T 2 C
215	419	T 2 D
200	392	T 3
180	256	T 3 A
165	329	T 3 B
160	320	T 3 C
135	275	T 4
120	248	T 4 A
100	212	T 5 *
85	185	T 6 *

Marking shall not exceed auto ignition temp of the atmosphere encountered.
* Non-heat producing equipment, with a temp of 100°C or less, need not be marked.

3.G.17.j(2) (a) Flame Arresters. Flame arresters are sometimes used in explosion-proof enclosures to reduce maximum explosion pressure and to protect any incoming air lines. Types of flame arresters include porous metal plugs made of sintered metal, a baffle-type breather similar to an automobile muffler, a special fitting with a loosely fitted thread, and a spiral wound corrugated metal fitting. These configurations causes the flame to spread through paths which cool the gases by heat transfer to the metal from the atmosphere or make the escaping explosion's hot gases turn sharp corners, allowing them to cool.

(b) Explosion-Proof Receptacles & Plugs. Explosionproof receptacles and plugs are designed as a pair. Mechanical interlocking is used between the plug and receptacle. When a plug is inserted, electrical contact cannot be made until the automated plug and receptacle assembly has established its explosionproof integrity. To prevent explosions from propagating, many threads are usually engaged before electrical contact is made or broken.

An explosionproof enclosure is not effective without sealed conductor entrances. Seal fittings allow an explosion to be contained within an enclosure; to prevent pressure piling and prevent the transmission of gases or vapors between enclosed electrical systems install in Division 1, Division 2, and ordinary locations. Seal fittings are usually attached by a short piece of rigid conduit to an enclosure for switches, circuit breakers, fuses, relays, resistors, or other apparatus which may produce arcs, sparks, or a high temperature. Not more than eighteen (18) inches of pipe or rigid conduit may be used, and at least five (5) full nipple threads must be engaged at each end. Explosionproof unions, couplings, elbows, capped elbows, and conduit bodies are the only permitted fittings between the sealing fitting and the enclosure. All such components, including the seal fitting and seal compound, must be approved by the testing laboratory for the intended purpose. Seal fittings are either shop fabricated or poured in the field. The cable gland is a relatively new type of seal. Use of a cable gland allows for a cable to be assembled in a clean shop environment and for simple field connection and installation. A more traditional sealing method uses a "poured" seal, which is completed in the field. The seal is poured after the cables have been brought into the enclosure. Mineral insulated cables require a different type of explosionproof seal fitting than shipboard marine cables.

k. Alterations &/or Repairs. Alterations to explosionproof equipment may destroy explosionproof protection. Explosionproof enclosures approved for certain applications, such as the installation of terminal strips, relays, etc., and may be internally modified to meet these intended applications within the limits specified in the approval. Explosionproof assemblies may not be modified in any way.

Enclosure modifications must are limited so that they do not affect piling from internal volume changes, impair flame-quenching paths and